Plastics Recycling 201

Preparation Time:	Easy-to-do	**Moderate**	Extensive

Grade:	9 – 12
Focus:	Plastics recycling
Subject:	Environmental Science
Materials:	Collection of plastic samples, "Plastics – The Basics," "Plastic Code Analysis," "Plastic Resins Identification Code" and "Take Home Science: Plastics Code and Packaging Survey" worksheets and handouts
Teaching Time:	Two class periods
Vocabulary:	Plastic Resin Identification Code, resin, polyethylene terephthalate (PET), high-density polyethylene (HDPE), lightweighting

Learning Objectives
Students will:

- recognize the significant role plastics play in our society;
- recognize the current limits to the recycling of plastics;
- recognize what products can be made from recycled plastic; and
- understand the coding system for plastics.

NOTE: This activity uses the **Plastic Resin Identification Code** (Code) established by the Society of the Plastics Industry (SPI). The SPI code was developed to provide manufacturers with a uniform system that would help recyclers and recycling programs identify the **resin** content of plastic bottles and containers commonly found in the residential waste stream. The codes (Numbers 1 through 7 surrounded by recycling arrows) are found on plastics products and packaging. Once you learn the code, you will find yourself examining the bottom of all kinds of plastic containers. Even though the SPI code uses recycling arrows, it does not mean the product is recyclable. Please check with your county recycling coordinator to find out what plastics are recyclable in your community.

Background
There are at least two absolute truths about plastic. Plastics are versatile. Plastics are everywhere. Plastics have the unique capability to be manufactured to meet specific needs for consumers. The versatility of plastic allows it to be used in everything from soft drink bottles to car parts, from televisions to clothing, from disposable diapers to medicine containers, from CD jackets to ketchup bottles, and from shower curtains to eating utensils. The list of products made from plastic (in whole or part) or packaged in plastic is endless.

It should not be surprising to know that plastics makes up a significant part of the nation's municipal solid waste (MSW) stream. What is MSW? It is the combined residential, commercial and institutional waste that we make. By weight, plastics accounted for 24.7 million tons or about 10.7 percent of the nation's MSW in 2000 according to the U.S. Environmental Protection Agency (U.S. EPA).

Overall, only about 5.4 percent or 1.3 million tons of plastic was recovered for recycling from the nation's MSW stream in 2000. But the recovery for recycling of some plastic containers was much more significant. About 34.9 percent (290,000 tons) of plastic soft drink bottles and about 30.4 percent (210,000 tons) of milk jugs and water bottles were recovered for recycling in 2000 according to the U.S. EPA. In South Carolina, about 25,588 tons of plastic was recycled in fiscal year (FY) 2002 (July 1, 2001 to June 30, 2002).

Did you ever notice the number surrounded by arrows on the bottom of the bottle? Do you know what the number means? The number is part of a coding system that refers to the resin that is used to make the bottle. Plastic soft drink bottles are made from **polyethylene terephthalate (PET)**. Plastic soft drink bottles and other bottles made from PET are designated No. 1.

Milk jugs and some water bottles are made from a different resin – **high-density polyethylene (HDPE)**. Products made from HDPE are designated No. 2. Review the Code to learn the different resins as well as the products and packaging made from those resins.

The SPI introduced the Code in 1988 at the urging of recyclers around the country. Recycling programs typically targeted packaging – primarily containers like soft drink bottles (No. 1) and milk jugs (No. 2). The coding system provides a way to identify the resin content of bottles and other containers commonly found in MSW.

The majority of recycling programs targeted and still target PET and HDPE bottles only - which makes perfect sense since about 95 percent of the bottles were made from those two resins. Other containers made from the resins 3 through 7 are not collected in the programs.

In the past few years, many recycling programs have converted to a new approach on plastics recycling – an all-plastic bottles program. This type of program does not mean all plastic bottles are recycled – in most programs only No. 1 and No. 2 bottles will be recycled while most if not all of the remaining bottles (3 through 7) will be removed from the collection and disposed of properly. The theory is an all plastic bottles program makes it much easier for consumers to recycle their plastic bottles because it eliminates the need for the consumer to check the number.

In addition, many recycling professionals believe that an all plastic bottles program increases the recovery rate of PET and HDPE bottles. Why? Again, about 95 percent of all plastic bottles produced are PET and HDPE, the theory is that with more bottles collected overall, the percentage of PET and HDPE bottles collected also will increase. Currently, there are about 12 all plastic bottle programs in South Carolina and about 2,000 programs nationwide.

The large-scale recycling of plastics faces many practical obstacles. First, just consider the sheer volume of products and packaging made from plastics. All of those products and packaging are made from different types of plastic that may look the same but needs to be sorted to be recycled.

Second, even under the best conditions, most plastics cannot be recycled into their original use. For example, an aluminum can or glass bottle can be recycled into a new aluminum can or glass bottle, respectively. Plastic soft drink bottles cannot be recycled into new bottles (they can be part of the bottle but not the entire bottle). In order to recycle many plastics, secondary uses must be found. But eventually, even second-generation plastic products such as lawn furniture made from milk jugs must be thrown away.

Third, the economics of recycling plastics are not always workable. For manufacturers, virgin resin prices traditionally have been lower than recycled resin prices. At a more local level, it can be more expensive to haul plastics because of their light weight than other recyclables like aluminum. And fourth, there are many plastic products and types of plastic packaging that cannot be recycled.

Still, plastics are recycled. The recycling and reuse of plastics has several beneficial economic and environmental impacts including saving natural resources, reducing the pollution created from extracting natural resources and, of course, conserving landfill space.

Plastics also often enable manufacturers to reduce the material used, energy consumed and waste generated in making a variety of products and packaging according to the American Plastics Council (APC). The plastics industry through a process called **lightweighting** has been able to reduce the amount of material needed to make packaging. Plastic milk jugs, for example, weigh 30 percent less than they did 20 years ago. Since 1977, the 2-liter plastic soft drink bottle has been reduced in weight from 68 grams to 51 grams, a 25 percent reduction per bottle that saves about 206 million pounds of packaging each year. Overall, plastic packaging generally is more lightweight than glass, metal and paper packaging. For example, plastic bags use less energy to produce than paper bags and conserve fuel and shipping. It takes seven trucks to carry the same number of paper bags as fits into a truckload of plastic bags.

Recycled plastic can be used in thousands of applications. Review the Code to learn what recycled content products are made from the different resins.

Learning Procedure
It may be beneficial to present this lesson in two parts – one to introduce plastics, assign students to look for plastics and bring in samples; and a second session to examine the types of plastics and recycling.

Part One

1. Introduce the topic of plastics. Brainstorm uses of plastic from milk jugs to auto parts to home siding. (Refer to the Lesson Resources and the background of this lesson.)

2. Provide students with copies of the handout Plastic Resins Identification Code and discuss it. Practice pronouncing the full name of each type of plastic.

3. Assign students to bring in samples of the types of plastic for the next session.

Part Two

4. Distribute copies of the "Plastic Code Analysis" handout. Have students share the plastic containers they brought to class. Have each student choose a plastic item and record the required information on their sheet.

5. After the students have recorded the data for all seven types of plastic, have them group the items by number. Discuss why a specific type of plastic was chosen for that product.

6. What types of plastic are recycled in your area? Share this information with the class.

7. What happens to plastic when it is recycled? What items are made from recycled plastic? Students may find shampoo bottles and other containers that are made from recycled plastic. Refer to the Plastic Resins Identification Code handout.

8. Discuss packaging options other than plastic such as glass, aluminum and paper. Which material makes the most efficient, cost-effective or recyclable packaging? If a product must be made from plastic, should consumers buy products made from plastic that can be recycled in their community?

9. Have students complete the "Take Home Science: Plastics Code and Packaging Survey" included in this lesson.

Extension Activity
Write a scenario for "A Day Without Plastics." Have students list the plastics they come into contact with in a typical day and what life would be like without them. Note the distinction between single-use plastics such as food wrappers, medical supplies and durable plastics including computer cabinets and automobile dashboards.

Wellman, Inc.

Wellman, Inc., an international Fortune 1,000 company with facilities in the United States (including Johnsonville, S.C.), the Netherlands, Ireland and France, manufactures fibers, plastic packaging and engineering resins made from both virgin and recycled materials. The company's products include Fortrel polyester, PermaClear PET packaging resin, EcoLon engineering resin and EcoSpun – a 100 percent-certified recycled polyester textile fiber.

In 1979, Wellman established its PET soft drink bottle recycling facility in Johnsonville, S.C. The company recycles PET bottles for use as a raw material in its polyester fiber operation. Wellman is the world's largest producer of polyester fiber made from recycled PET bottles and one of the world's largest polyester recyclers.

Wellman, Inc. is one of the world's largest recyclers of plastics with the capability of reclaiming nearly 3 billion PET bottles annually from around the world. For more information about Wellman, visit www.wellman.com.

STUDENT HANDOUT

Plastics – The Basics

What are plastics?

Plastics are any of various complex organic compounds produced by polymerization, capable of being molded, extruded, cast into various shapes and films, or drawn into filaments used in textile fibers – Webster's Dictionary.

How are plastics made?

Plastics are made from materials found in nature – oil, natural gas and coal. Basic compounds of carbon, hydrogen, oxygen and nitrogen are extracted and combined to produce different resins (similar to a cooking "batter"). Plastic manufacturers melt the resins and add chemicals. The hot liquid is molded under pressure and hardens into a plastic container. Most plastic containers are made from one of six primary resins.

In more technical terms, plastics are polymers. OK, what is a polymer? A polymer is something that is made of many units. Think of a polymer as a chain. Each link in the chain is the "-mer" or basic unit that is usually made up of carbon, hydrogen, oxygen and/or silicon. To make the chain, many links or "-mers" are hooked or polymerized together. Linking strips of paper to make garlands or hooking paper clips to form a chain can demonstrate polymerization. To create polymers, petroleum and other products are heated under controlled conditions and broken down into smaller molecules called monomers. The monomers are the building blocks for polymers. Different combinations of monomers product plastic resin with different characteristics such as strength or molding capacity.

Plastics can be divided into two major categories: thermosets and thermoplastics. A thermoset is a polymer that solidifies or sets irreversibly when heated. Thermosets are valued for their durability and strength and are primarily in automobiles and construction. Others are used for adhesives, inks and coatings. A thermoplastic is a polymer that softens when exposed to heat and returns to its original condition when cooled to room temperature. Thermoplastics can be shaped and molded easily and are used for products such as soft drink bottles, milk jugs, floor coverings, credit cards and carpet fibers.

Plastic resins are processed in several ways including extrusion, injection molding, blow molding and rotational molding. All of the processes involve using heat and/or pressure.

How are plastics recycled?

Plastic is collected from recycling programs and taken to a materials recovery facility where they are sorted from other recyclables. The plastic is sorted by type, baled and sent to a reclaimer. At the reclaiming facility, the plastic is passed across a shaker screen to remove dirt and trash, washed and ground into small flakes. The flakes are placed in a flotation tank to separate contaminants and then are dried, melted, filtered and formed into pellets. The pellets are shipped to manufacturing plants to be made into new products.

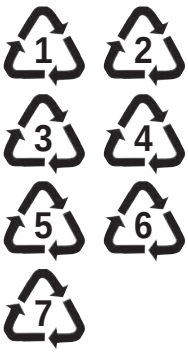
Wellman, Inc., an international Fortune 1000 company with facilities in the United States (including Johnsonville, S.C.), the Netherlands, Ireland and France, manufactures fibers, plastic packaging and engineering resins made from both virgin and recycled materials. The company's products include Fortrel polyester, PermaClear PET packaging resin, EcoLon engineering resin and EcoSpun – a 100 percent certified recycled polyester textile fiber.

In 1979, Wellman established its PET soft drink bottle recycling facility in Johnsonville, S.C. The company recycles PET bottles for use as a raw material in its polyester fiber operation. Wellman is the world's largest producer of polyester fiber made from recycled PET bottles and one of the world's largest polyester recyclers.

Wellman, Inc. is one of the world's largest recyclers of plastics with the capability of reclaiming nearly 3 billion PET bottles annually from around the world. For more information about Wellman, visit www.wellman.com.

Name: _____

Plastic Code Analysis

NUMBER/ SYMBOL	LETTER CODE	PRODUCT NAME	PACKAGE PROPERTIES	CAN YOU RECYCLE IT?	OPTIONAL PRODUCTS
	PET or PETE, HDPE, V or PVC, LDPE, PP, PS, OTHER	In this column, write the name of the product.	Describe the package using terms like flexible, rigid, transparent, opaque, translucent, color, white creases form when crushed.	Is the package recyclable in your area? Yes or no.	Is there another product choice that would be recyclable or reusable? List.

Plastic Resins Identification Code

Codes	Descriptions	Properties	Product Applications	Products With Recycled Content
 PETE	**Polyethylene Terephthalate (PET, PETE).** PET is clear, tough, and has good gas and moisture barrier properties. Commonly used in soft drink bottles and many injection molded consumer product containers. Other applications include strapping and both food and non-food containers. Cleaned, recycled PET flakes and pellets are in great demand for spinning fiber for carpet yarns, producing fiberfill and geo-textiles. Nickname: Polyester	Clarity, strength, toughness, barrier to gas and moisture, resistance to heat	Plastic soft drink, water, sports drink, beer, mouthwash, catsup and salad dressing bottles. Peanut butter, pickle, jelly and jam jars. Ovenable film and ovenable prepared food trays	Fiber, tote bags, clothing, film and sheet, food and beverage containers, carpet, strapping, fleece wear, luggage and bottles.
 HDPE	**High Density Polyethylene (HDPE).** HDPE is used to make bottles for milk, juice, water and laundry products. Unpigmented bottles are translucent, have good barrier properties and stiffness, and are well suited to packaging products with a short shelf life such as milk. Because HDPE has good chemical resistance, it is used for packaging many household and industrial chemicals such as detergents and bleach. Pigmented HDPE bottles have better stress crack resistance than unpigmented HDPE bottles.	Stiffness, strength, toughness, resistance to chemicals and moisture, permeability to gas, ease of processing, and ease of forming.	Milk, water, juice, cosmetic, shampoo, dish and laundry detergent bottles; yogurt and margarine tubs; cereal box liners; grocery, trash and retail bags.	Liquid laundry detergent, shampoo, conditioner and motor oil bottles; pipe, buckets, crates, flower pots, garden edging, film and sheet, recycling bins, benches, dog houses, plastic lumber, floor tiles, picnic tables, fencing.
 V	**Polyvinyl Chloride (PVC/Vinyl).** In addition to its stable physical properties, PVC has good chemical resistance, weatherability, flow characteristics and stable electrical properties. The diverse slate of vinyl products can be broadly divided into rigid and flexible materials. Bottles and packaging sheet are major rigid markets, but it is also widely used in the construction market for pipes and fittings, siding, carpet backing and windows frames. Flexible vinyl is used in wire and cable insulation, film and sheet, floor coverings, synthetic leather products, blood bags, medical tubing and other applications.	Versatility, clarity, ease of blending, strength, toughness, resistance to grease, oil and chemicals.	Clear food and non-food packaging, medical tubing, wire and cable insulation, film and sheet, construction products such as pipes, fittings, siding, floor tiles, carpet backing and window frames.	Packaging, loose-leaf binders, decking, paneling, gutters, mud flaps, film and sheet, floor tiles and mats, resilient flooring, cassette trays, electrical boxes, cables, traffic cones, garden hose, mobile home skirting.

Plastic Resins Identification Code

Codes	Descriptions	Properties	Product Applications	Products With Recycled Content
 LDPE	**Low Density Polyethylene (LDPE).** Used predominately in film applications due to its toughness, flexibility and relative transparency, making it popular for use in applications where heat sealing is necessary. LDPE is also used to manufacture some flexible lids and bottles and it is used in wire and cable applications.	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Dry cleaning, bread and frozen food bags, squeezable bottles, e.g. honey, mustard.	Shipping envelopes, garbage can liners, floor tile, furniture, film and sheet, compost bins, paneling, trash cans, landscape timber, lumber
 PP	**Polypropylene (PP).** Polypropylene has good chemical resistance, is strong, and has a high melting point making it good for hot-fill liquids. PP is found in flexible and rigid packaging to fibers and large molded parts for automotive and consumer products.	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture.	Catsup bottles, yogurt containers and margarine tubs, medicine bottles	Automobile battery cases, signal lights, battery cables, brooms, brushes, ice scrapers, oil funnels, bicycle racks, rakes, bins, pallets, sheeting, trays.
 PS	**Polystyrene (PS).** Polystyrene is a versatile plastic that can be rigid or foamed. General purpose polystyrene is clear, hard and brittle. It has a relatively low melting point. Typical applications include protective packaging, containers, lids, cups, bottles and trays.	Versatility, insulation, clarity, easily formed	Compact disc jackets, food service applications, grocery store meat trays, egg cartons, aspirin bottles, cups, plates, cutlery.	Thermometers, light switch plates, thermal insulation, egg cartons, vents, desk trays, rulers, license plate frames, foam packing, foam plates, cups, utensils
 OTHER	**Other.** Use of this code indicates that the package in question is made with a resin other than the six listed above, or is made of more than one resin listed above, and used in a multi-layer combination.	Dependent on resin or combination of resins.	Three and five gallon reusable water bottles, some citrus juice and catsup bottles.	Bottles, plastic lumber applications.

Reproduced with permission of the American Plastics Council (APC)

DOWN to Earth

Plastics engineers work to do more with less material. Since 1977 the 2-liter plastic soft drink bottle has been reduced in weight from 68 grams to 51 grams, a 25 percent reduction per bottle that saves 206 million pounds of packaging each year according to the American Plastics Council.

STUDENT WORKSHEET *Name:* _____

Take Home Science: Plastics Code and Packaging Survey

DIRECTIONS: Select a location for your survey, either at home or a grocery store. Look for 25 items made of plastic and record the product name, number symbol and letter code. Record whether the item is recycled in your community. If not, is the same product available in a container that can be recycled in your area?

Where did you do your survey? ____ Home ____ Grocery Store

Which rooms at home? _____ Which aisles at the store? _____

Product Name	Number and Letter Code	Can you recycle it? **YES** or **NO**	Product Packaging	Is the same product available in a different packaging? **YES** or **NO**
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

ANALYZE YOUR DATA

Count how many times you found each code. ____#1, ____#2, ____#3, ____4#, ____5#, ____6#, ____#7

Which type was found the most? _____ The least? _____

Based upon what is recyclable in your area, how many of the plastics you found are recyclable? _____

What percentage of the plastics you found are recyclable? _____

Based on your findings, could you increase the amount of recyclable plastics by changing your buying habits? _____

How many products did you find with different types of packaging? _____

Which types of packaging can be recycled in your community? _____